

the surface itself is concerned is admitted, but whether the Riemann space is identical with, or only analogous to, spherical space in a hyperspace of four dimensions remains a subject of controversy between the author of the book and M. Mansion. At any rate, M. Lechalas does not discuss space of positive curvature independently of its connection with four-dimensional Euclidean space, and accordingly the book contains only one more chapter devoted to the geometry of Lobatchefsky and Bolyai. In this respect the treatment is analogous to that given in some books on conics where the properties of the ellipse are proved by three-dimensional methods (orthogonal projection) and those of the hyperbola by plane geometry. Whether this is the best plan is open to question; many mathematicians seem to prefer it, and an author cannot please everybody.

In his preface, which is printed in *italics*, M. Tannery fairly well defines the scope and object of his book. Although this is a second edition, it has been entirely re-written. It is primarily intended for readers who do not possess a very extended knowledge of mathematics. It covers mainly those portions of analysis which are commonly found in English text-books on higher algebra, viz. properties of irrational numbers, continued fractions, aggregates, convergency and divergency of series and of infinite products, the binomial theorem, the exponential and logarithmic series, and expansions of trigonometric functions treated without the aid of imaginaries. Finally, we have a chapter on derived functions containing applications of the formula

$$f(x+h) - f(x) = hf'(x + \theta h),$$

and an illustration of functions which have no differential coefficient. The subject-matter may all be included under the heading "functions of real variables treated algebraically," as M. Tannery has avoided the use of geometrical methods in the present volume. A second volume is promised dealing with functions of complex variables, in which geometrical methods are to be freely used.

The treatment is clear and full, and the book gives the impression of being as good an exposition of the subject as could well be written on the lines laid down by the author. It does not profess to give historical or bibliographical information, for which the reader is referred to the "Mathematical Encyclopædia," of which the French edition is now coming out.

An interesting insight into the thoughts of two eminent mathematicians is afforded by the first volume of correspondence between Hermite and Stieltjes, covering the period 1882-1889. The intimacy seems to have arisen in 1882, out of a letter addressed by Stieltjes to Hermite dealing with a theorem of M. Tisserand relating to the expansion of the disturbing force when the mutual inclination of two orbits is considerable. The subject-matter of this letter (which is missing from the collection) was published in the *Comptes rendus* for November 13, 1882.

At this time Thomas Jean Stieltjes was attached
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to the Observatory of Leyden, and the influence of Hermite doubtless accounts in large measure for his activity in mathematical research during the years which followed, culminating in his migration to France in 1885, after his failure to obtain a mathematical chair in his own country.

A noteworthy feature of Stieltjes's work is his partiality for simple arithmetical tests of general theorems. The value of his examinations of numerical details must have been enormous to a man of Hermite's calibre. It seems as if Hermite in many cases furnished the ideas which Stieltjes elaborated and extended. It was not with Stieltjes alone that Hermite carried on an extensive correspondence, for he was evidently fond of writing letters, and even many of his contributions to journals appeared in epistolary form. But among his various correspondents Stieltjes played a prominent part, and it was Hermite's own wish that the letters of his colleague should be published after the premature death of the latter in 1894. One thing is unfortunately wanting. Hermite was to have written an introduction, but he did not live to do so. In its place we have a preface by M. Picard and a biographical notice by M. H. Bourget, who, in conjunction with M. Baillaud, were colleagues of Stieltjes in the University of Toulouse from 1886 until his death, and who have jointly edited the present volume.

It would be difficult to give a general summary of the subject-matter of this correspondence, which deals with continued fractions, hypergeometric series, Legendre's functions, semi-convergent series, and, indeed, analysis generally. Portraits of Hermite and Stieltjes complete the volume. There is a certain brightness and freshness about the way one of the two mathematicians writes to the other announcing some new result and the second takes up the clue and develops it, and one can imagine the delight that the two kindred spirits must have had in working together.

While the volumes before us are widely different in character, it may be well to warn the busy reader, as has been done on previous occasions, that they all possess one objectionable feature in common. While the guillotine was originally invented in France, the modern instrument of that name has not been applied to its proper use on the pages of any one of the series, consequently readers, unless they are prepared to set up a private guillotine, are compelled to waste hours in hacking and jaggging the leaves with a paper knife, producing a very untidy result.

G. H. B.

THE MUTATION THEORY OF THE ORIGIN OF SPECIES.

Species and Varieties: their Origin by Mutation. By Hugo de Vries. Edited by D. T. MacDougal. Pp. xviii+847. (London: Kegan Paul and Co., Ltd., 1905.)

AT the present time, when naturalists are beginning to turn again to the problem of the origin of species, this account of Prof. de Vries's theories and experiments is sure of a welcome, partly

as the most recent exposition of that naturalist's views and researches, and partly as the first account of them available in the English language.

It has been maintained by those who attack biological problems by methods by which they insist that they do not hope to account for anything, that it is idle to attempt to explain the phenomena of variation and heredity until they have been adequately described; and although it is certain that the danger of a too premature attempt to account for things is greater among those who use methods by which they believe the fundamental nature of the things will ultimately be revealed than it is among statistical evolutionists, it does not follow that it is better to adopt the second course on account of these (really not very dangerous) pitfalls in the first. Of the possibility of adopting it without falling into them at all Prof. de Vries's work is a rare example. The book before us consists of twenty-eight lectures delivered at the California University by Prof. de Vries, and prepared for the press by Mr. D. T. MacDougal. It will be of immense value to the student whose lack of knowledge of German renders "*Die Mutations-theorie*" a sealed book to him, as well as to the investigator; but two features of it, which result from the mode of its origin, render it a less valuable work than "*Die Mutationstheorie*." One of them, which affects the student and general reader, is the absence of illustrations; the other, which affects the investigator, is the absence of references, which is a real drawback in a book that puts into circulation the details of many unfamiliar and interesting breeding experiments.

Seeing that this book is likely, and intended, to appeal to the student, there is one feature of it which might have been different with advantage; and we believe the defect to be serious, because the general reader will notice it as little as he will deplore the absence of pictures much.

The publication of a book in which there is set forth for the student a new and profoundly important biological theory, and a collection of facts in support of it, seems to us to have been a most suitable opportunity for discarding that scientific jargon which is still believed to have a meaning by those who do not understand it, and still used by those who know that it means nothing. In the very first sentence it appears in its old vigour.

"Newton convinced his contemporaries that natural laws rule the whole universe. Lyell showed, by his principle of slow and gradual evolution, that natural laws have reigned since the beginning of time."

Of course Prof. de Vries and Mr. MacDougal know that natural laws do not really rule the universe, and that they have not reigned since the beginning of time, and that this latter expression stretches even poetical licence. But the general reader and student do not know this, and when they see this kind of statement scattered through scientific literature they can be pardoned for going away with the idea that there must be laws existing somewhere ruling and reigning and being obeyed, and that it is the business of the man of science to discover them.

A few examples from the body of the book will suffice. For instance, on p. 3, "If an origin by natural laws is conceded for the latter, it must, on this ground, be granted to the first also"; on p. 90, "... wild species, which obey the laws discussed in a previous lecture"; on p. 175, "... and liable to reversions by the ordinary laws of the splitting up of hybrids"; and on p. 547, "The physiological laws, however, which govern this process are only very imperfectly revealed by such a study."

We are perfectly aware that such expressions are continually to be found in the memoirs of men of science who in their other writings have exposed the meaninglessness of such phrases; but this only leads to the necessity of a stronger insistence on the desirableness of discarding them, in the conviction that the curious image of nature which such expressions call up would be less erroneous and more eradicable than it is now if they were never used.

The fact that entirely different things sometimes have the same name leads to the need for caution in the interpretation of another expression the meanings of which are about as numerous and as different as those of the term "law." The word regression in Prof. de Vries's book denotes a biological phenomenon of singular interest; but it must not be forgotten that it is also the name of a purely statistical conception. It is very necessary that these two significations should be kept absolutely distinct in the mind of the reader.

The book is, considering its bulk, very free from misprints; the few that occur do not lead to any difficulty, e.g. "begining" on p. 118, "hundred" on p. 475, "of" for "on" in the last line of p. 560. There is one inconsistency of spelling; Macfarlane is spelt thus on pp. 21 and 268, and with a capital F on p. 255. We have some doubt as to which is the more correct, "morphologic" or "morphological," though we have none as to which is the more euphonious; but surely one or the other should be used throughout; yet on p. 141 we find "morphological" and on p. 144 "morphologic," and similarly on p. 144 "physiologic" and on p. 547 "physiological," on p. 709 "empiric" and on p. 733 "empirical."

We think that scant justice is done to the greatness of Mendel's work and to the conceptions based upon it which bid fair to put us on the track of accounting for some of the phenomena of heredity; and by confining Mendel's law to the description of the mutual properties of varieties only, the meaning and tendency of Mendelian investigation that is now being carried on seem to be missed. That Hurst can predict the difference between the result of mating two pairs of rabbits externally identical, by means of a knowledge of the difference between their gametic constitutions acquired by previous breeding from them, constitutes, it seems to us, the longest stride the study of heredity has made for some time past.

The zoologist who confines himself as strictly to the study of animals as Prof. de Vries does to that of plants will be disappointed if, trusting to the comprehensiveness of the title of the book, he expects to

find as much about the one half of living nature as about the other in it.

The most fruitful source of progress is a new way of looking at things, and such new points of view result in the destruction of old classifications and the need for new ones; in biology, investigators will soon cease to be classified according to the group of animals or plants with which they deal, but according to the particular phase of the problem of the "fundamental nature of living things" (which is the ultimate goal of biological inquiry) which interests them. In the study of heredity, for example, there is already a number of investigators who are as familiar with that phenomenon in the case of animals as in the case of plants. Nor does it seem reasonable to doubt that, by thus broadening the basis of material used by the investigator, the conclusions arrived at by him are likely to be less wide of the truth than they are apt to be if they are based on the result of experiment with a single animal or plant. The moral of this is, not that Prof. de Vries ought to have said something about animals in his book, but that the disappointed zoological reader ought to know something about plants for the sake of his work.

To bestow praise on any work of Prof. de Vries would be impertinent; to cite points of particular interest in the book is unnecessary, for it has already begun to form part of the indispensable equipment of the student of evolution in the broadest sense of that term. A. D.

ASPHALT PAVEMENTS.

The Modern Asphalt Pavement. By Clifford Richardson. Pp. vii+580. (New York: John Wiley and Sons; London: Chapman and Hall, Ltd., 1905.) Price 12s. 6d. net.

THIS is a book dealing with an important practical subject which up to the present time has not received much attention from writers of text-books. Asphalt pavements of various kinds are now so largely used that a text-book dealing with this subject has been a long-felt want.

The book is divided into sections, and the author has appended to the end of each chapter a brief summary of the matter dealt with, enabling the reader to determine quickly whether or not the chapter contains the information he is seeking for. The first section deals with the construction of the road base upon which the surface carrying the traffic is supported, and it is evident that Mr. Richardson is of opinion that the ideal base is hydraulic concrete. Between this base and the surface proper is interposed a binder, or intermediate, course; where the traffic is heavy, the best material for this is a layer of compact asphaltic concrete. The next section is concerned with the materials employed in making the asphalt surface mixture, and a detailed account is given of the sands used for this purpose and of their origin and physical characteristics. After a brief explanation and classification of the various hydrocarbons of which native bitumen is composed, the author describes the native bitumens which have so far been used in paving work.

In section iv. the technology of the paving industry is taken up; the preparation of the surface mixture is explained with the help of elaborate tables, and the theory which underlies the practical work is described; the author points out that an asphalt surface in order to be successful must resist both weathering and impact. The mechanical appliances used for combining the various materials into the surface mixture are described with diagrams.

Sections v. and vi. deal with the handling of the material in the street and with the hand-tools needed by the workmen, and in the latter section a description of an ingenious machine for impact tests is given. In section vii. there is a complete specification for an asphalt pavement; this will be found of great value to engineers who have to draw up specifications for work of this nature. Mr. Richardson points out that the popular idea as to the limiting gradient for an asphalt pavement is erroneous, and that in the eastern part of the United States, for example, a gradient of 8 per cent. on an asphalt road is not excessive. There is no doubt that asphalt has great advantages when compared with most of the other pavement materials; it is free from mud if properly washed down at regular intervals; unlike wood, it is practically non-absorbent; when kept in a clean condition it gives a good foothold for horses; tractive effort is considerably reduced, and even under heavy traffic asphalt wears remarkably well. Although the initial cost is heavy, still the cost of upkeep is lower than that for most of the other paving materials. The last section of the book, one of the most valuable, deals with the testing of the various materials used in asphalt pavement work; it gives a complete account of this necessary branch of the work, and data are given of the equipment required in a municipal laboratory where such testing work is carried out.

The book is likely to prove of great value to municipal authorities who are faced with the problem of determining the most satisfactory road material to employ both where traffic is heavy and where it is moderate. T. H. B.

OUR BOOK SHELF.

Die physikalischen Eigenschaften der Seen. By Dr. Otto Freiherr von und zu Aufsess. Pp. x+120. (Brunswick: Vieweg and Son, 1905.) Price 3 marks.

THERE are many books and pamphlets dealing with one or several of the properties of lakes; the aim, however, of the present work is to gather into a handbook the principal facts known, and to give a general view of the results arrived at, so as to incite the lover of nature to interesting observations as well as to provide a guide for the more specialised limnologist.

In a short introduction the author deals with Prof. Forel's work as having caused the important development of limnology which recent years have witnessed, and gives this authority's definition of a lake as being "a mass of still water, closed up on all sides, situated in a depression of the ground, without direct communication with the sea." The lake surface being a part of the earth surface represents a section of a sphere, the curvature of the same being, with large